FOAM-X SORBENT EVALUATION

Prepared by:

PRAIRIE REGIONAL OIL SPILL CONTAINMENT AND RECOVERY ADVISORY COMMITTEE RESEARCH AND DEVELOPMENT SUBCOMMITTEE

for:

MITCHELL ENTERPRISES

and

ALBERTA RESEARCH COUNCIL

January, 1989

CANADIAN PETROLEUM ASSOCIATION

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Sorbent Evaluation

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Prepared for:
Research and Developmemt Sub-Committee of the
Prairie Regional Oil Spill Containment and Recovery Advisory
Committee

and

The Alberta Research Council

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1.0 INTRODUCTION

Laboratory tests were conducted in December 1988 on "Foam-X", a shredded polyurethane foam sorbent, manufactured by Mitchell Enterprises of Calgary, Alberta. The tests were conducted by the PROSCARAC Research and Development Sub-Committee of the Canadian Petroleum Association and the Alberta Research Council.

The tests' objective was to conduct a preliminary evaluation of the sorbent's potential to: absorb oil, retain oil, and to reduce a hydrocarbon's flammability.

The objectives were accomplished with:

- -Canadian Standards Absorbency Test
- -Water Column Visual Analysis
- -Surface Oil Retention Visual Analysis
- -Gas Chromatograph Vapor Analysis

It was not the purpose of the tests to examine:

- -the environmental and human health toxicological properties.
- -the feasibility of applying Foam-X in outdoor spill situations.
- -other hazardous materials which may be recovered using Foam-X.
- -Foam-X's commercial market potential.
- -disposal options for recovered Foam-X / Oil.

It was also not the purpose of these tests to compare the benefits of Foam-X sorbent versus other commercially available sorbents. Each sorbent has characteristics which make it beneficial to a specific application. The tests described in this report give only an initial indication of Foam-X's potential and are therefore not conclusive.

Foam-X is currently manufactured as a "Floor Dry" sorbent for machine leakage, fluids and spills on the plant floor.

1.1 Sorbents

Sorbents are designed to absorb petroleum based products while repelling water (ie: They are oleophilic & hydrophobic). They are placed on the surface of an oil slick where they recover the spilled oil by either adsorption, in which the oil is attracted to the sorbent surface and then adheres to it, or absorption, in which the oil penetrates into the pores of the sorbent material.

Sorbents are generally marketed in particulate form for spreading over a slick, or as sheets, rolls, pillows, or booms. The sorbent material can consist of natural products such as peat or straw, mineral compounds such as ash, vermiculite, or perlite, and most commonly synthetic products such as polyethylene, polypropylene or polyurethane.

Foam sorbents have a distinct cellular structure (or matrix) which does not depend on the nature of various oils to provide coherence of the oil/sorbent mixture. An open cell polyurethane foam supplies a large surface area of porous material with open ended interconnected pores. The total volume of the pores per unit of sorbent weight should be as large as possible, thereby reducing the surface tension between the hydrocarbon and sorbent.

An online literature search of five databases revealed 11 documents which discuss particulate polyurethane sorbents. Although, not totally relevant to the same type of properties as Foam-X, the documents are referenced in Section 5.

Throughout this report, when reference is made to the word "absorb" or "absorption", it should be interpreted as a general reference to either the properties of absorption or adsorption.

2.0 THE TESTS

To date, Foam-X has not been used in a commercial or oil spill situation. The oleophilic and hydrophobic properties of the sorbent have only been demonstrated at the manufacturer's Calgary warehouse. On the basis of floor tests conducted by the manufacturer, absorbency ratios between 12 and 17.5 have been claimed. The absorbency ratio is the weight of oil absorbed per unit weight of sorbent.

All Foam-X tests discussed in this report were done with the actual sorbent compound as supplied. In actual commercial usage, the product may appear in other forms such as socks or pillows which could alter the absorbency ratios.

Foam-X was tested with two other particulate sorbents: a chemically dried peat moss and a powdered vermiculite. (Figures 1, 2 & 3). Both these sorbents have been previously marketed as oil sorbents.

Table 1
Comparison of Sorbent Densities

Foam-X:	.052 g/ml
peat moss:	.120 g/ml
vermiculite:	.123 g/ml

Four hydrocarbon test media were used in the tests and are summarized in Table 2.

Table 2
Test Media

	Density (g/ml) @ 15°C	Viscosity (cp)
Diesel Fuel	0.830	12.8 @ 38°C
Norman Wells Crude (light)	0.832	7.0 @ 15°C
Alberta Sweet Mixed (medium)	0.839	9.2 @ 15°C
Prudhoe Bay Crude (heavy)	0.899	35.0 @ 15°C

No tests were conducted with weathered oil. All tests were performed in a controlled laboratory environment.

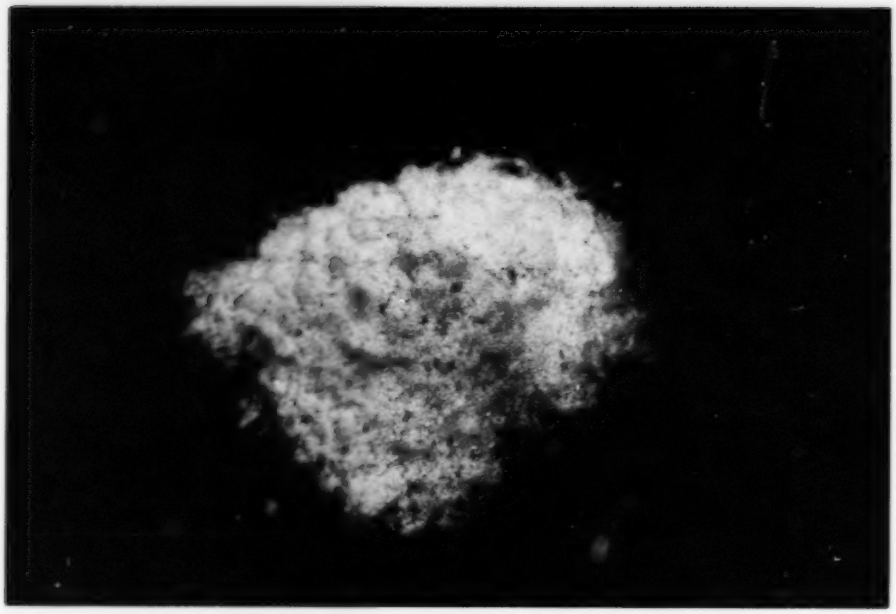

FIGURE 1: Foam-X Sorbent.

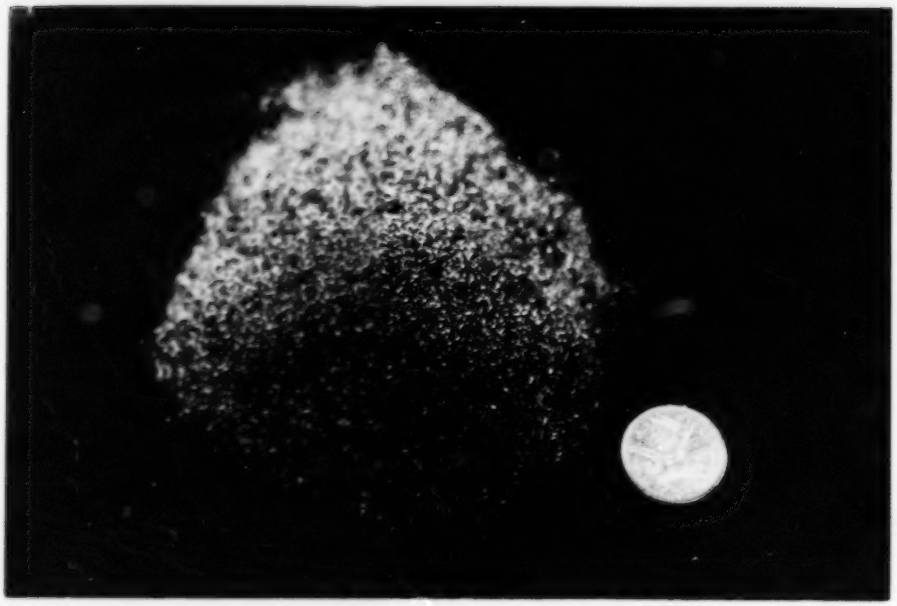

FIGURE 2: Vermiculite Sorbent.

FIGURE 3: Peat Moss Sorbent.

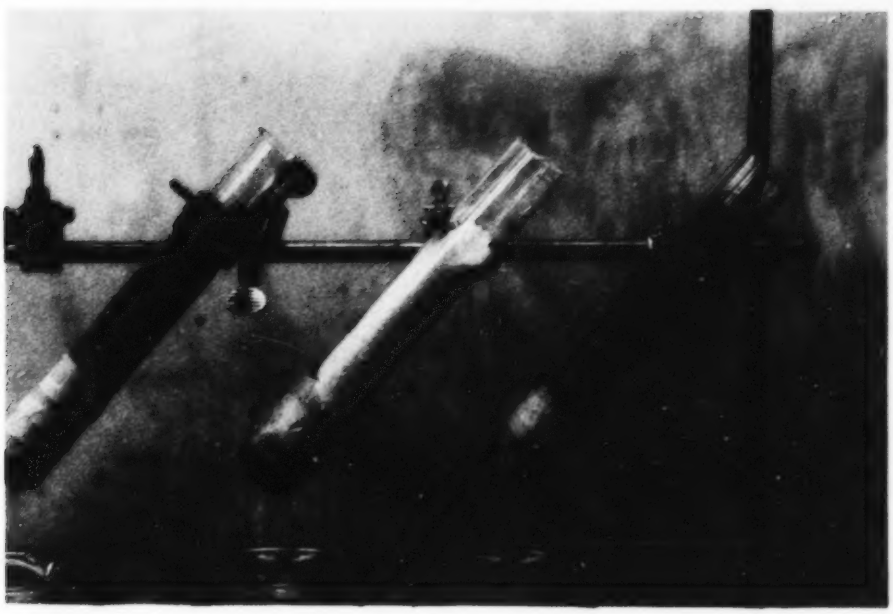

FIGURE 4: Canadian Standards Absorbency Test.
Vermiculite, Foam-X & Peat Moss before adding oil.

2.1 Canadian Standards Absorbency Test

Absorbency tests on the three sorbents, Foam-X, vermiculite, and peat moss, were conducted using a variation of the Canadian General Standards Board Test 25-GP-1, Method 44.1. Results are shown in Table 3.

Test Method:

- -A No. 18 metal screen was taped over one end of a glass tube measuring 225 mm in length and 30mm inside diameter.
- -The clean, dry tube was weighed and then filled 2/3 to 3/4 full (15 to 17 cm) with sorbent. The sorbent was poured, without tamping, into the tube to simulate actual application conditions.
- -The filled tube was re-weighed to determine the amount of sorbent.
- -The tube was mounted at a 30° angle to the horizontal for testing water and fuel absorbency and 60° for oil absorbency. (Figure 4)
- -100ml of test fluid was then poured into the tube. (Figure 5)
- -Absorbtion was allowed to progress for a minimum of 6 hours.
- -The amount of water or oil absorbed was determined by re-weighing the tube.
- -The absorbency ratio, expressed in grams per gram, is determined by dividing the weight of absorbed fluid by the dry absorbent.

Results:

Table 3
Canadian Standards Absorbency Test
Absorbency Ratios (gm/gm)

Sorbent	Water	Diesel	Prudhoe Bay	Norman Wells	Alberta Sweet
Vermiculite	4.1	3.50	3.79	3.27	3.74
Peat Moss	0	4.27	4.54	4.02	4.11
Foam-X	0	7.76	6.66	7.40	7.59

- -All tests, with the exception of water, were conducted inside a laboratory fume hood. Therefore the absorbency ratios may be conservative with evaporation occurring during the tests. Estimated evaporation varied between 7 and 15%.
- -Both the peat moss and Foam-X did not allow water to penetrate the sorbent column. Only 35 ml of water could be applied in both cases. The peat moss did not pick up water like natural peat moss due to chemical drying. (Figure 6)
- -Reference #1 confirms similar ratios for peat moss.

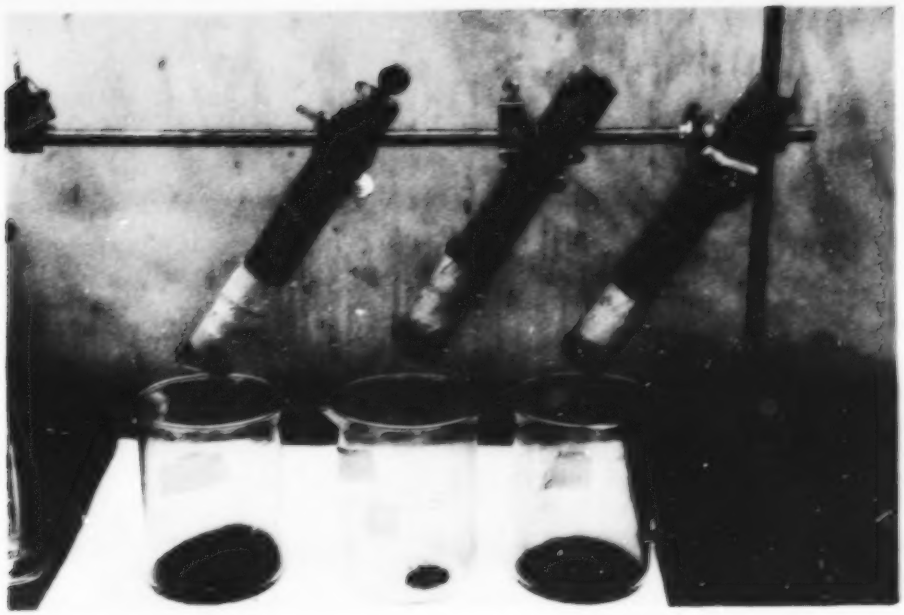

FIGURE 5: Prudhoe Bay absorbency test after 1 hour; Left to right: Vermiculite, Foam-X & Peat Moss.

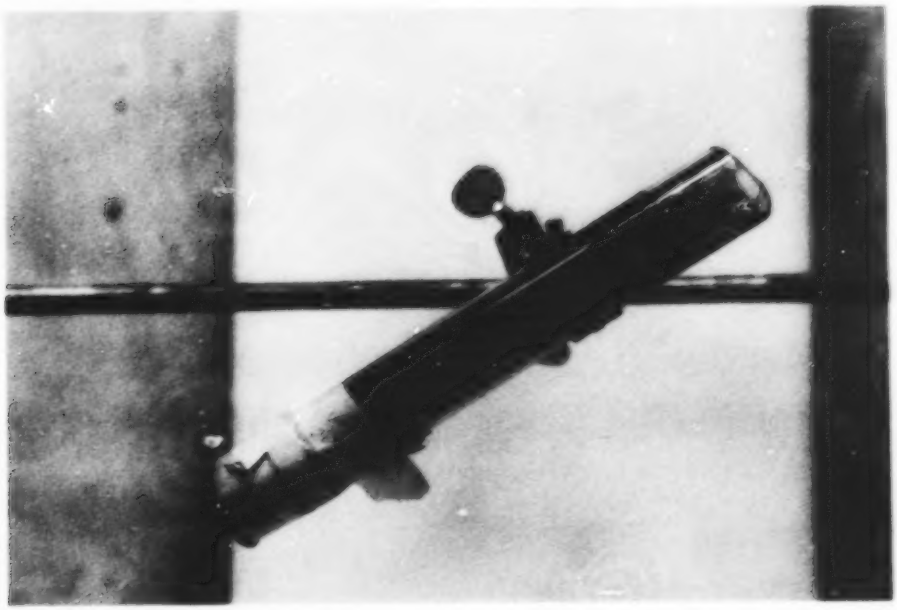

FIGURE 6: Water absorbency test on Peat Moss.

2.2 Water Column Visual Analysis

The purpose of this test was to visually inspect the sorbents' capability to retain absorbed oil on the water surface. The test was an effective visual analysis of the sorbents' bouyancy and retention properties.

Test Method:

- -Using 500 ml graduates, 25 ml of each oil was placed in 400 ml of water. (Figure 7)
- -In separate graduates, 25 ml of sorbent (vermiculite, Foam-X and peat moss) were added. (Figure 8)
- -Once it was apparent that complete ab/adsorption had taken place, the sorbent/oil compound was thoroughly mixed into the water column.
- -The mixtures were let to stand for 6 hours.

-This was a visual test only, no chemical analysis was done of the water column.

-Reference #9 presents a test where the % Sorbent/Oil afloat in water after 6 hours of mixing is given for polyurethane chips and vermiculite. The results compare favourably with the present tests.

Results: (Figures 9 to 16)

Foam-X:
For all oils after mixing, the Foam-X immediately separated the oil from the water and rose to the surface. After a stand period of 6 hours, both the water column and graduate bottom showed no visual appearance of sorbent or oil.

Peat Moss:
For all oils after mixing, the peat moss and oil remained in a cloudly suspension in the water column for 5 minutes. After the 6 hour stand period, some suspension was still apparent however, a thin film (2 ml) of particulate had settled to the bottom of the graduate.

Vermiculite:
Although the vermiculite did absorb the oil sooner than the peat moss, a cloudy water column remained throughout the stand period for all tests. A 5 ml film on the graduate bottom appeared with all oil tests.

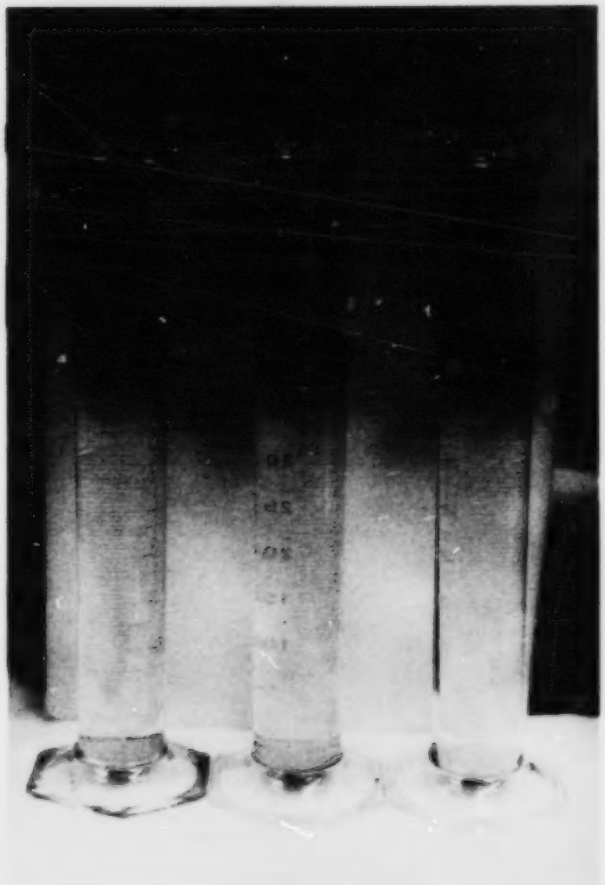

FIGURE 7: Water Column Test.
Norman Wells before adding sorbent.

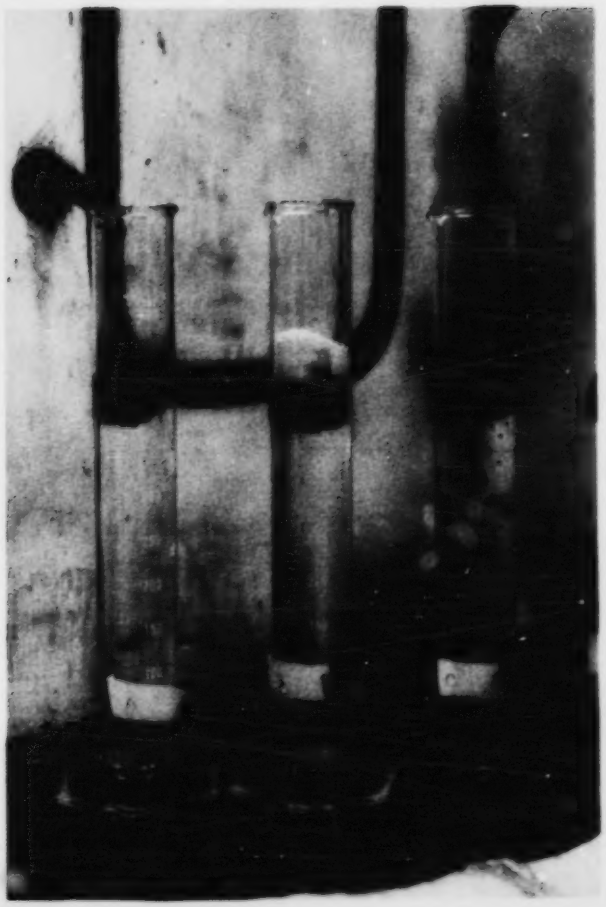

FIGURE 8: Water Column Test.
Norman Wells with sorbent before mixing.
L-R: Peat Moss, Foam-X, Vermiculite

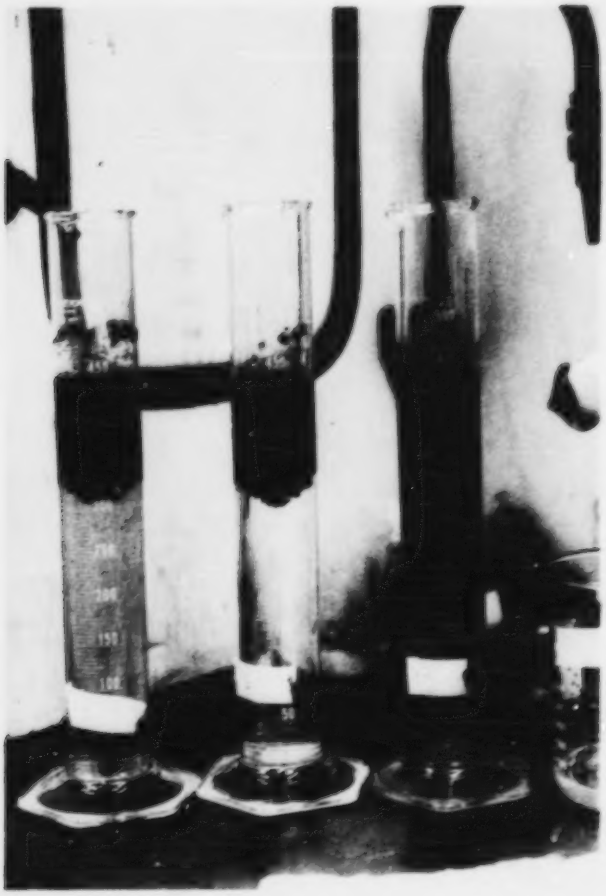

FIGURE 9: Water Column Test.
Norman Wells 1 minute after mixing.
L-R: Peat Moss, Foam-X, Vermiculite

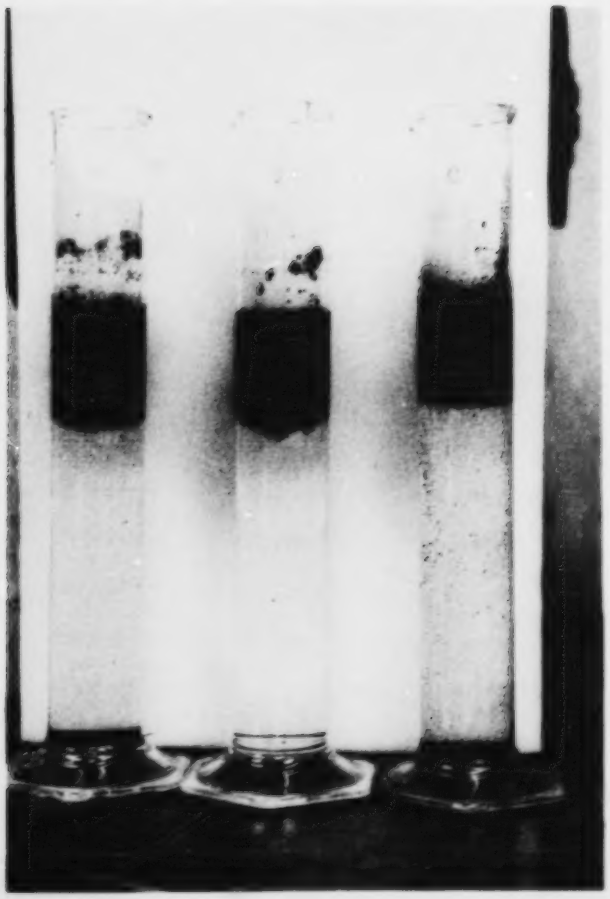

FIGURE 10: Water Column Test.
Norman Wells after 6 hours.
L-R: Peat Moss, Foam-X, Vermiculite

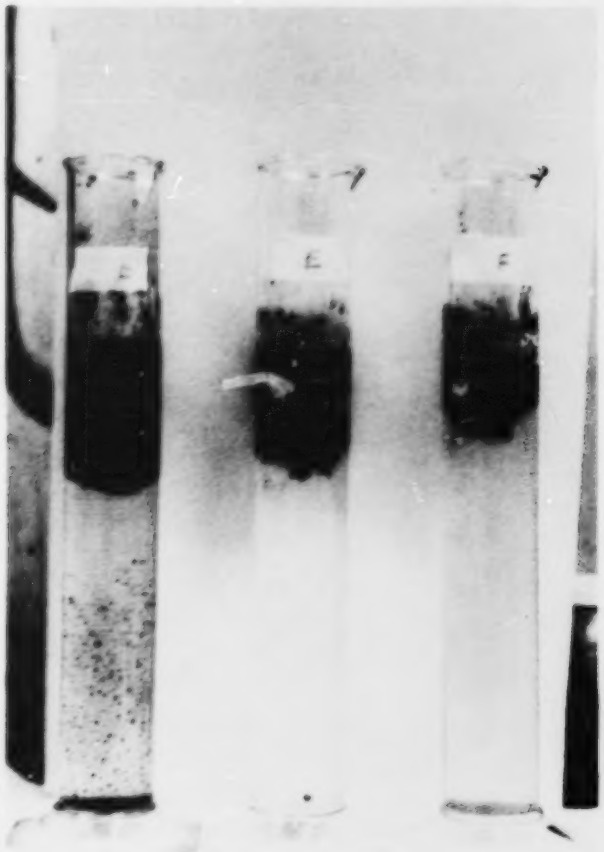

FIGURE 11: Water Column Test.
Alberta Sweet 5 min. after mixing.
L-R: Peat Moss, Foam-X, Vermiculite

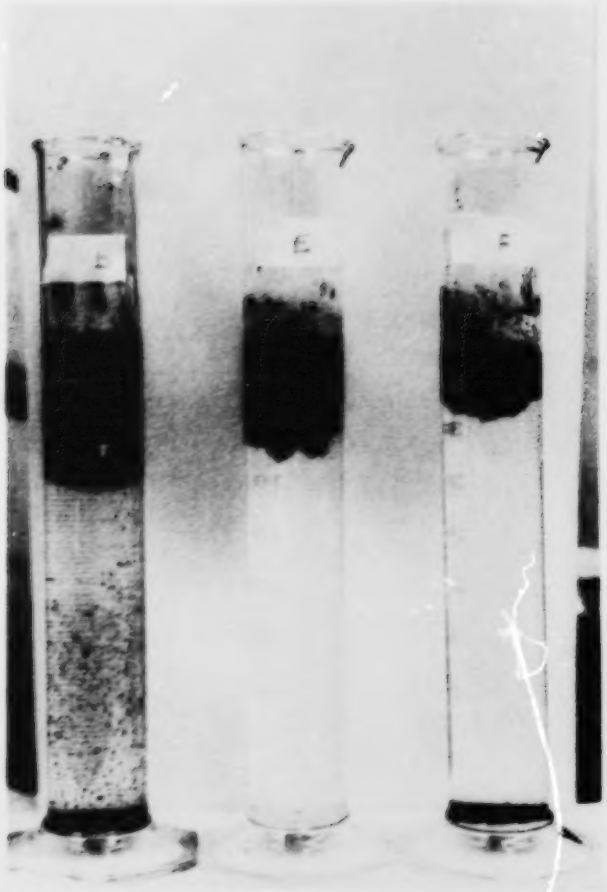

FIGURE 12: Water Column Test.
Alberta Sweet after 6 hours.
L-R: Peat Moss, Foam-X, Vermiculite

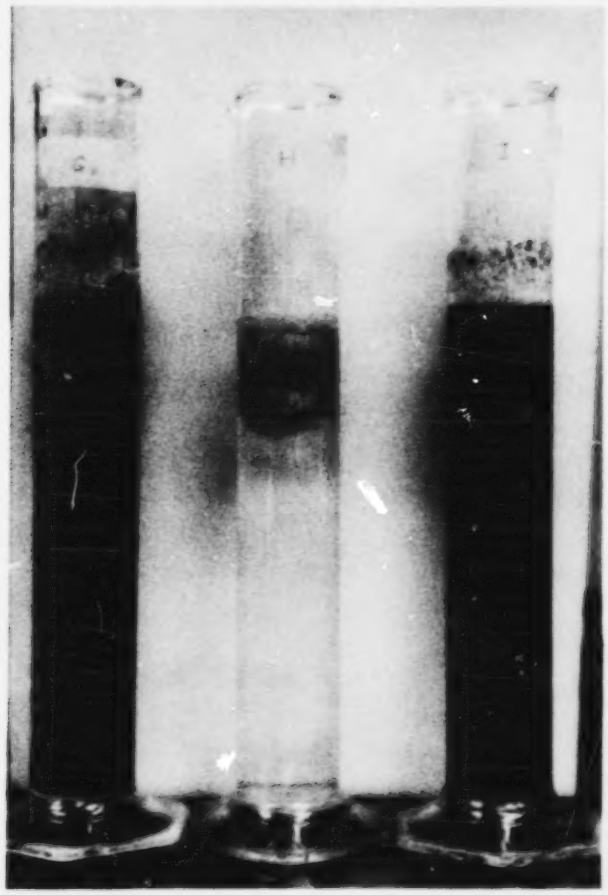

FIGURE 13: Water Column Test.
Diesel 1 minute after mixing.
L-R: Peat Moss, Foam-X, Vermiculite

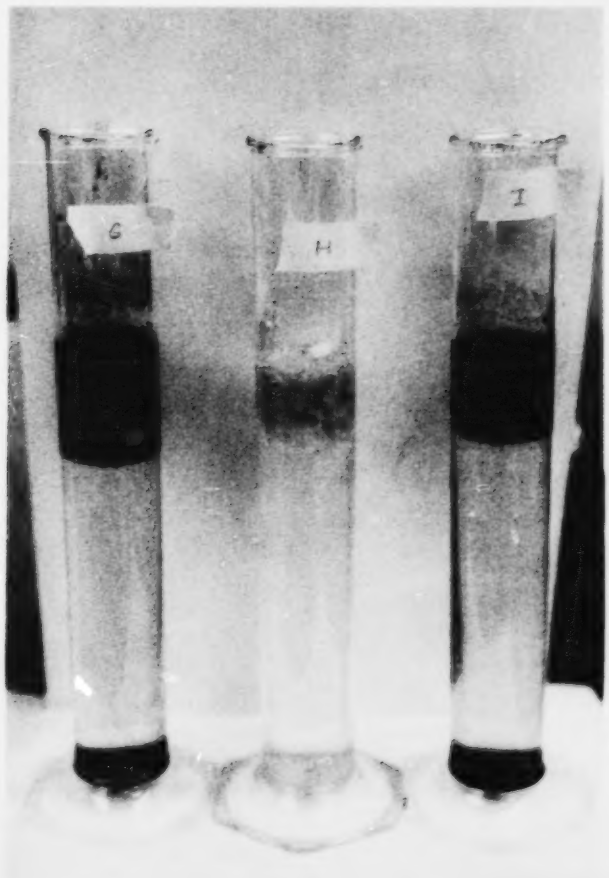

FIGURE 14: Water Column Test.
Diesel after 6 hours.
L-R: Peat Moss, Foam-X, Vermiculite

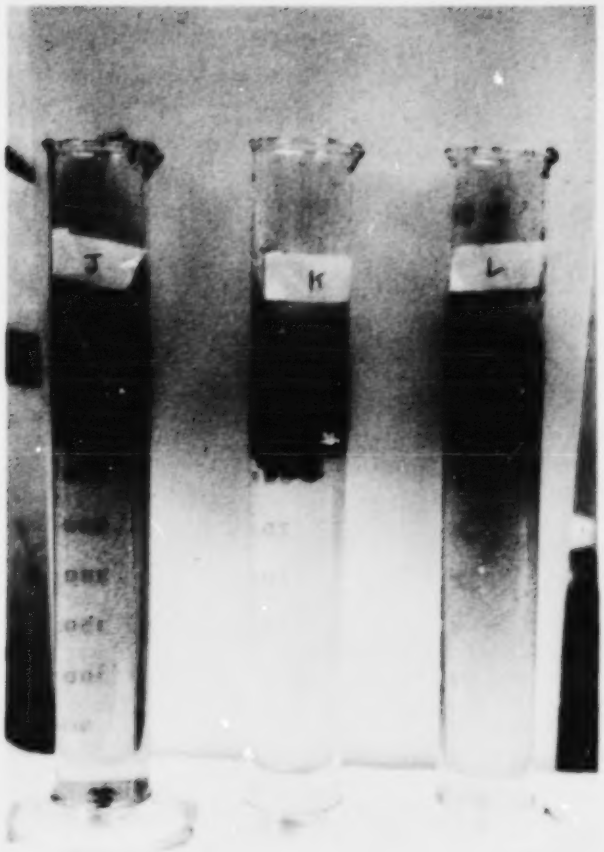

FIGURE 15: Water Column Test.
Prudhoe Bay 1 minute after mixing.
L-R: Peat Moss, Foam-X, Vermiculite

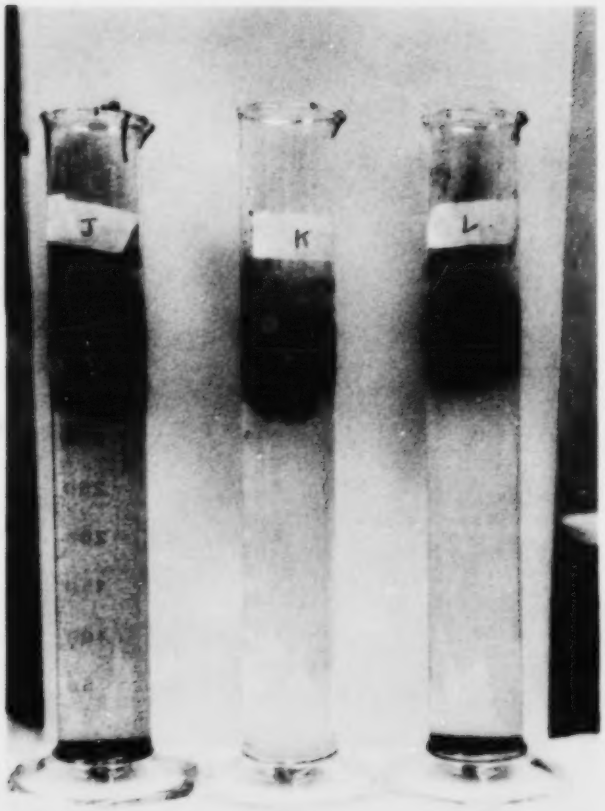

FIGURE 16: Water Column Test.
Prudhoe Bay after 6 hours.
L-R: Peat Moss, Foam-X, Vermiculite

2.3 Surface Oil Retention Visual Analysis

The particulate sorbents' potential to retain absorbed oil over time is also a measure of the sorbent's effectiveness.

Test Method:

The three sorbents were individually applied in a 25/75% sorbent/oil ratio to the four oils. The mixtures were allowed to stand for 12 hours on a laboratory surface.

Results:

Visual examination showed that no oil had migrated away from the sorbents in any cases. (Figures 17 & 18)

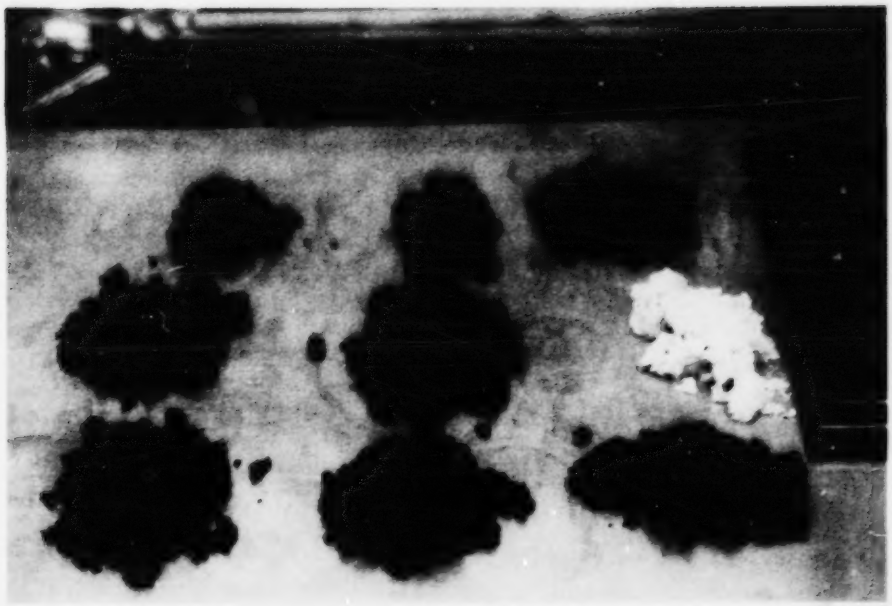

FIGURE 17: Surface Oil Retention Analysis at 1 minute.
Rows, top to bottom: Prudhoe Bay, Diesel, Alberta Sweet.
Columns, left to right: Peat moss, Foam-X, Vermiculite.

FIGURE 18: Surface Oil Retention Analysis at 12 hours.
Rows, top to bottom: Prudhoe Bay, Diesel, Alberta Sweet.
Columns, left to right: Peat moss, Foam-X, Vermiculite.

2.4 Gas Chromatograph Vapor Analysis

Mitchell Enterprises had previously demonstrated that the odour from a diesel or gasoline surface spill (floor) is non-existent after the application of Foam-X.

This would reduce the flammability and the explosive hazard of the fuel by reducing its vapor pressure.

Test Method:

Vapour samples were analysed by gas chromatography. The samples were taken above both diesel fuel and a 50/50 by volume diesel fuel / Foam-X mixture. The upper and lower flammability limits following the application of Foam-X were not tested.

Results:

The chromatograph results in Table 4 and Figures 19 & 20 illustrate that there were no traces of hydrocarbons in the vapor following the application of Foam-X to the diesel.

TABLE 4
Vapor Gas Chromatograph Results

Component	Weight %		Mole %	
	Diesel Vapor	Diesel & Foam-X Vapor	Diesel Vapor	Diesel & Foam-X Vapor
Air	95.797	100.00	99.380	100.00
iC5	0.130	0.00	0.030	0.00
nC5	0.172	0.00	0.040	0.00
C6	0.361	0.00	0.070	0.00
C7	0.550	0.00	0.091	0.00
C8	0.957	0.00	0.139	0.00
C9	1.256	0.00	0.163	0.00
C10	0.742	0.00	0.087	0.00
Other	0.036	0.00		
	100.000	100.00	100.000	100.00

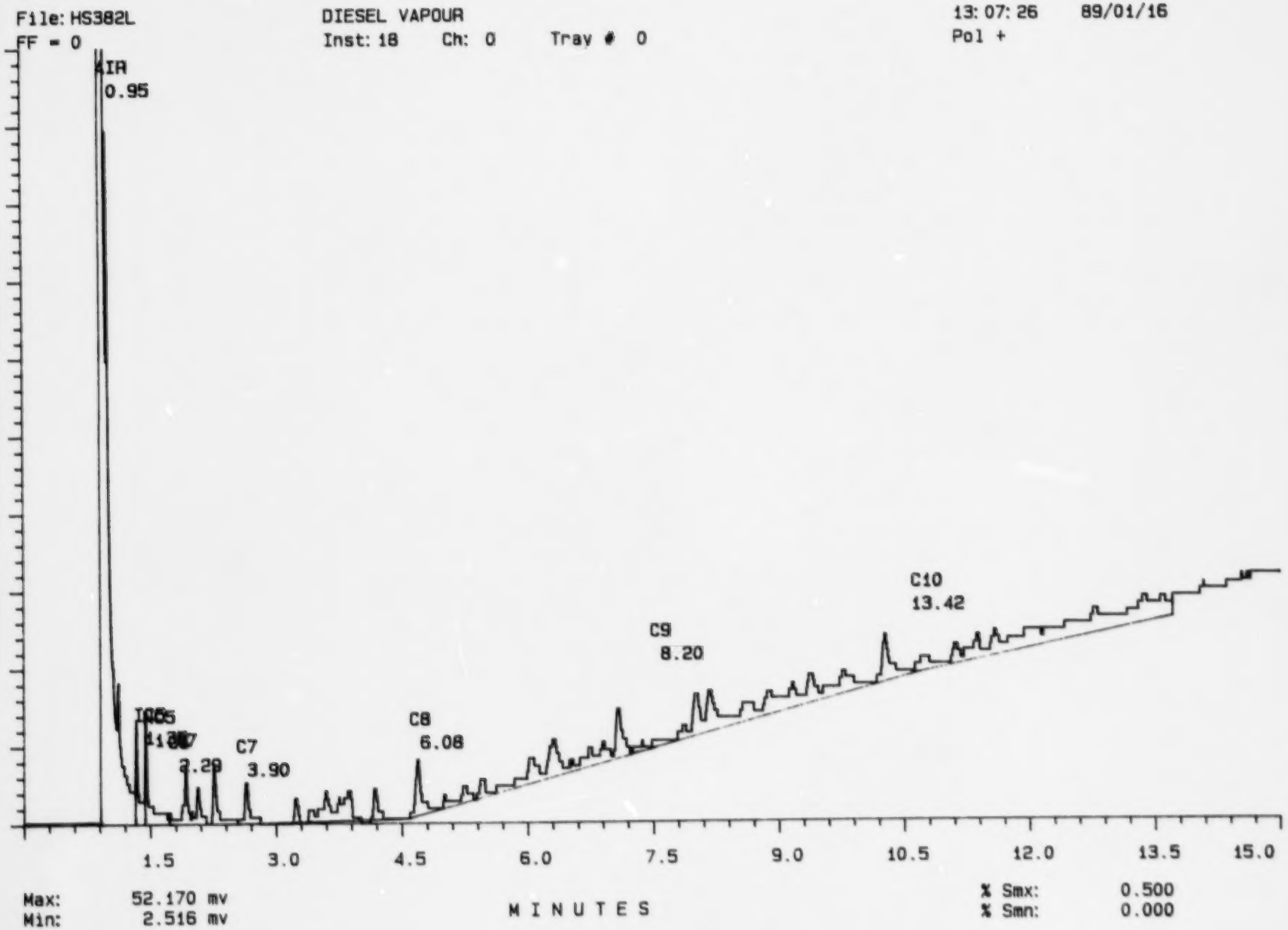

FIGURE 19: Gas Chromatograph Results Vapor over Diesel Fuel'

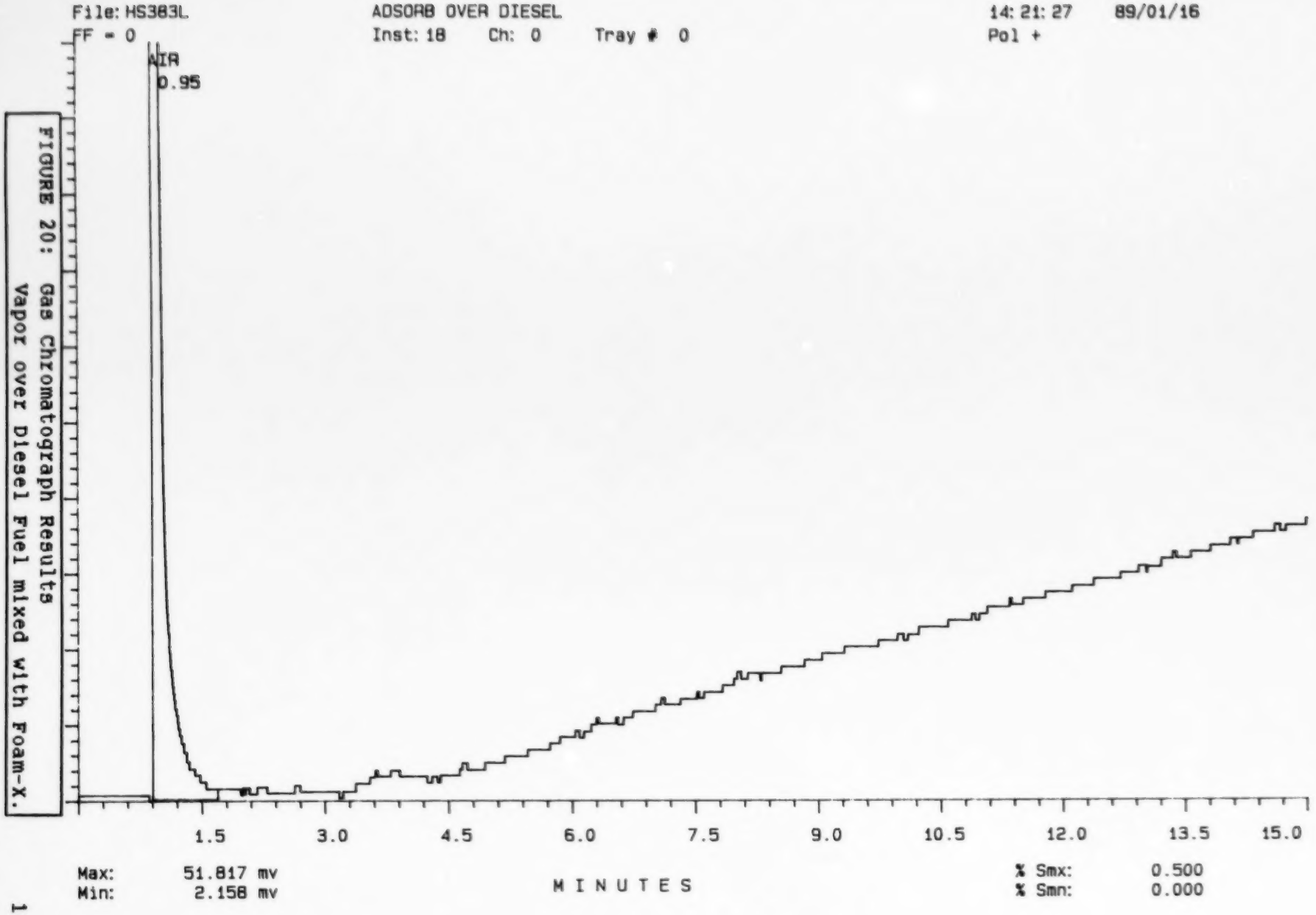

FIGURE 20: Gas Chromatograph Results
Vapor over Diesel Fuel mixed with Foam-X.

2.5 Reuseability Test

Mitchell Enterprises has claimed that recovered oil can be centrifically removed from the Foam-X. It was also claimed that Foam-X can be reused up to 8 times with little reduction of its absorbency capabilities. Also, Reference #10 quotes tests that demonstrate that oiled foam sorbent absorbs oil more efficiently than dry foam.

Although the committee feels that there is little need to reuse a particulate sorbent in a spill situation, the possibility to recover absorbed oil has economic potential.

A centrifuge test at 10,000 rpm for 60 seconds recovered 75% of absorbed oil.

2.6 Additional Tests

When the parameters of the Foam-X tests were initially designed, it was proposed to compare the sorbent capacities of Foam-X to other commercially available sorbents. All the sorbents would be tested for the following:

-Initial Optimum Capacity - the total amount of oil that a particular sorbent is capable of picking up on its initial exposure to oil.

-Retention Capacity - the amount of oil that a particular sorbent is capable of retaining after a drainage period.

-Re-use Capacity - the amount of oil that a particular sorbent is capable of picking up after being wrung or squeezed.

The test method for sheet or batt sorbents did not allow an effective comparison with particulate sorbents and were therefore discontinued. However, the results are presented here for informational purposes only. These results do correlate with past tests described in References 1, 2, & 3.

Sorbents tested:

Conweb D	- low density polyethylene foam sheets
SPC	- synthetic sheets
Graboil	- polyurethane foam mats
Pig	- absorbent socks

Test Method:

-Sorbent sections were soaked in the test oil for 1 minute, weighed for initial absobency, and hung for drainage. (Figure 21)

-They were reweighed at times of 1, 10, and 30 minutes following initial oil contact.

Results:

The results in Tables 5, 6 & 7 are expressed in grams oil absorbed per gram of sorbent. The one Foam-X test (Alberta Sweet Mix) required the use of a sieve to contain the oil. (Figure 22)

Table 5
Sorbent Tests
Alberta Sweet Mix

Sorbent	Initial Absorbency g/g	1 Minute Absorbency g/g	10 Minute Absorbency g/g	30 Minute Absorbency g/g
Conweb D	25.23	22.28	20.21	17.56
SPC	11.85	10.58	8.83	7.89
Graboil	29.89	11.32	9.20	8.14
Pig	.43	.43	.43	.43
Foam-X	10.62	10.20	9.90	9.69

Table 6
Sorbent Tests
Prudhoe Bay Crude

Sorbent	Initial Absorbency g/g	1 Minute Absorbency g/g	10 Minute Absorbency g/g	30 Minute Absorbency g/g
Conweb D	18.72	17.40	16.40	16.30
SPC	14.16	10.28	8.48	7.75
Graboil	27.25	13.03	8.65	8.19
Pig	2.60	2.54	2.52	2.51

Table 7
Sorbent Tests
Diesel

Sorbent	Initial Absorbency g/g	1 Minute Absorbency g/g	10 Minute Absorbency g/g	30 Minute Absorbency g/g
Conweb D	22.00	13.80	11.50	9.80
SPC	10.10	7.07	6.03	5.75
Graboil	16.50	8.27	7.44	7.08
Pig	4.01	3.54	3.23	3.22

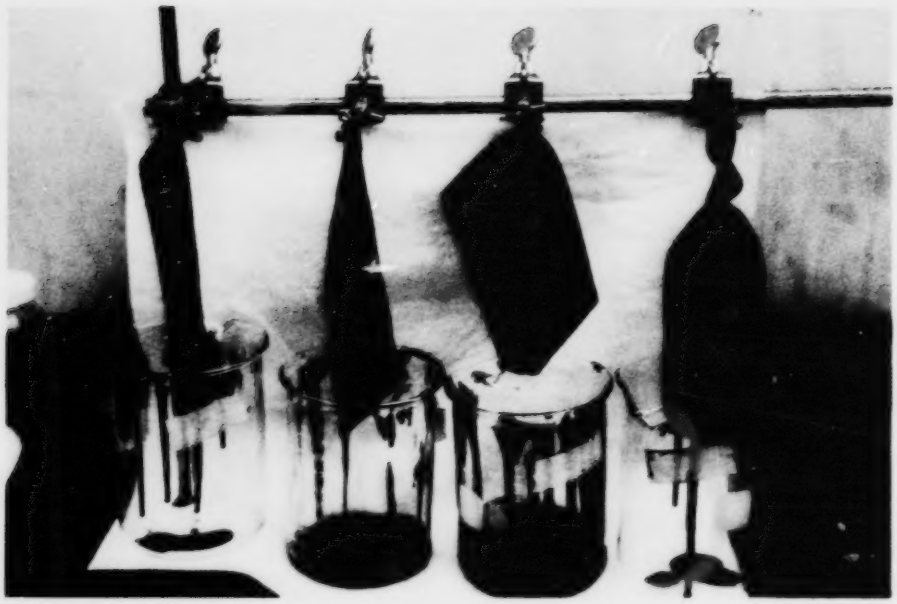

FIGURE 21: Absorbent Drip Tests, Alberta Sweet, 1 minute. (L-R: Conweb D, SPC, Graboil, Pig.)

FIGURE 22: Sieve Test on Foam-X, Alberta Sweet.

3.0 CONCLUSIONS

1. The Foam-X sorbent is capable of ab/adsorbing significant amounts of oil per unit weight of sorbent with relatively short contact times. The low density of the Foam-X and the fact that not all the Foam-X was contacted by the oil in the inclined tube test suggests that higher absorbency ratios are possible.

2. Foam-X sorbent is 100% hydrophobic. It is able to maintain ab/adsorbed oil on the water surface without any visual effect to the water column.

3. Oil can be effectively recovered from Foam-X.

4. Foam-X appears to reduce the release of vapors from spilled hydrocarbons.

4.0 RECOMMENDATIONS

Foam-X appears, on the basis of this report's brief tests, to have excellent ab/adsorption properties. It is both strongly oleophilic and hydrophobic. Once oil has been absorbed, Foam-X's low density keeps the oil floating on the water surface. The oil is not released to the water column, nor does it sink or mix with the water.

A full range of tests on environmental toxicity and health properties should be conducted.

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